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Poster paper

Prototype testing of a composite-type active grating bender with Si substrate for surface profile high-order term elimination

T.-C. TSENG†, S.-Y. PERNG, H.-S. FUNG, S.-W. LIN, J.-C. SYU, K.-H. HSU AND C.-T. CHEN
National Synchrotron Radiation Research Center, Taiwan

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The previous monolithic active grating bender design met some basic design requirements. However, after a real grating (BM-AGM) had been fabricated and installed for testing, the results showed that the usable length is a mere 60 mm because of the higher-order term error in the surface profile. A method was thus derived to eliminate the higher-order term error by modifying the width of the bender substrate through finite-element method simulation, reducing the residual error from about 100 nm to 6 nm. Owing to the closure of the grating department of Zeiss, ruling the monolithic bender is no longer available and the design has to be modified to a composite-type bender with Si substrate. A prototype was fabricated and assembled to examine all the design situations. The surface roughness of the width-modified Si substrate is around 30 nm before assembly. The residual error after assembly and bending is less than 10 nm. It proves that the design is feasible. However, due to the manufacturing capacity of the vendor, a short-length substrate is required and the design has to be modified. The detailed design modification and testing results are presented in this paper.

1. Introduction

The active grating was designed to increase the resolution with the reduction of the coma and defocus aberrations, by using an adjustable bender to control the surface profile to a desired third polynomial order. The previous tests revealed that the linkage-type bender design meets the basic mechanical requirement. However, the higher-order term error of the surface profile that induces the residual error larger than 10 nm after a third-order polynomial fitting subtraction, will limit the usable length. A method was thus derived to eliminate the higher-order term error by modifying the width of the bender substrate through FEM (finite-element method) simulation (Huang *et al.* 2009). Originally, the bender was of monolithic design but difficult to rule and only Zeiss could manufacture it. But since the grating department of Zeiss has closed, the design was thus modified to a composite-type bender with Si substrate.

† Email address for correspondence: tctseng@nsrrc.org.tw

FIGURE 1. The assembled grating bender prototype.

2. Composite-type bender design and testing result

The prototype design was modified according to a 250 mm length Si substrate to minimize the side effect at the clamping area. The symmetry side modification formula to eliminate the higher-order term is derived through iteration as

$$b(x) = 23.98459 + 5.42598\mathrm{E} - 5x^2 - 1.13895\mathrm{E} - 8x^4 + 1.34455\mathrm{E} - 12x^6.$$

The assembled prototype is shown in figure 1. The surface roughness of the width-modified Si substrate is around 30 nm before assembly. The residual error after assembly and bending is less than 10 nm as shown in figure 2. It proves that the design is feasible.

3. New bender design for AGM-AGS

Due to the budget consideration, a new grating vendor in Japan demands a shorter Si substrate of 220 mm length because of manufacturing capacity. The design has to be modified for the AGM-AGS (Active Grating Monochromator – Active grating Spectrometer) beamline design at TLS (Taiwan Light Source) (Fung *et al.* 2009). Again, through iteration, the symmetry side modification formula to eliminate the high-order term is derived as

$$b(x) = 24.76917 + 3.35182\mathrm{E} - 4x^2 - 2.31194\mathrm{E} - 7x^4 + 2.18159\mathrm{E} - 11x^6.$$

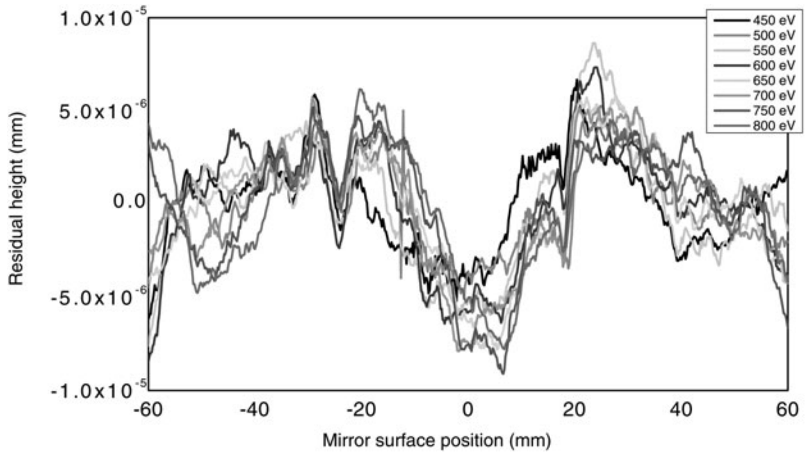

FIGURE 2. Testing result of the assembled grating bender prototype.

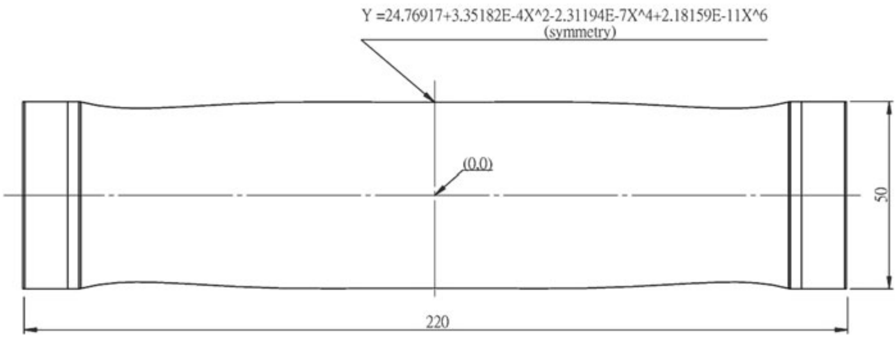

FIGURE 3. The redesigned Si substrate figure.

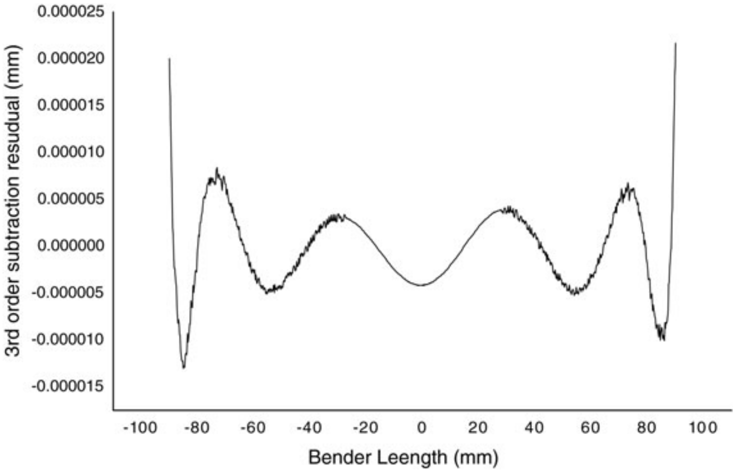

FIGURE 4. The third-order substraction residual simulation by FEM.

The redesigned Si substrate figure is shown in figure 3 and the third-order subtraction residual simulation by FEM is shown in figure 4. It shows that the side effect is a little bit large but in the required 160 mm area the error is still within 10 nm.

4. Conclusion

A surface profile higher-order term elimination method has been developed for manufacturing the active grating at National Synchrotron Radiation Research Center. The results of prototype testing show good agreement to the simulation. A new pair of composite-type gratings was redesigned according to the vendor manufacturing capacity and is now under fabrication for the AGM-AGS beamline at TLS.

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